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Owensboro, Kentucky

Quarterly Report No. 3

Interim Technical Report on

# The Investigation of Synthetic and Substitute Materials in Domestic Supply for Use as Vacuum Tube Spacers.

For Period - 1 February, 1952 to 30 April, 1952

Date of Report - June, 1952

CONTRACT NO: NObsr 52535

Submitted by:

J. C. Hickle
Project Engineer

Approved by:

A. P. Haase
Special Development Engineer

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## TECHNICAL PERSONNEL ADDED DURING THIRD INTERVAL

Richard J. Coswell

Date of Birth: February 20, 1926

Place of Birth: Detroit, Michigan

Education & Experience: BA (1947), MS (1949) Univ. of Southern California. General Electric Company, March 1949 Chemet Program 1949-1950

# ABSTRACT

Evaluation of the physical characteristics of modifications of terratex and other asbestos based materials has continued.

Several new materials have been received and evaluated as to physical characteristics and performance in tubes.

New processing techniques for terratex are discussed and evaluated.

Results on tubes using many of the promising materials are presented and discussed with particular emphasis on ease of degassing and level of cathode emission.

Technical man hours during this interval:

| | |
|---|---|
| RM Broderick) | |
| RJ Coswell ) | 155 |
| Paul Doigan ) | |
| AP Haase | 27 |
| JC Hickle | 203 |
| MA Chernin | 322 |

The total expenditures on this contract through April 30, 1952 have been $18,955.84.

# PURPOSE

The object of the work carried on under this contract is to find or develop a domestic material or materials to be used as vacuum tube spacers to replace or supplement the presently used mica.

The primary aim of the work will be to find a suitable material that will compete with mica in cost and ease of fabrication.

The major problems in connection with the fulfilment of this contract are:

1. Find a material of suitable strength and flexibility to allow standard assembly techniques to be used.

2. A material of such a nature that it may be fabricated to the standard tolerances used for mica at low cost and in large quantities.

3. Physical and chemical properties such that it may be degassed easily and not carry or contain elements or compounds detrimental to any of the other parts, particularly the oxide-coated cathodes.

4. A material or materials which will give equivalent electrical characteristics without major design changes in the structure of the tube; e. g., (emission, transconductance, leakage, capacitance, shock resistance, vibration, microphonics and noise).

## General Factual Data

Our work during the third interval has continued to be devoted to evaluating the physical and chemical properties of asbestos-based and mica-based sheet materials.

Variations in the asbestos-based material have been along two separate lines. First, the clay content of the asbestos sheet has been varied and the strength and other properties measured. Second, further attempts have been made to vary the processing of the regular terratex material in order to decrease the gas and moisture content. It is felt that any improvement of this type in the regular terratex could also be applied to the other asbestos-based materials. The investigation of the effect of different clay contents in the asbestos sheet was carried out on two different lots of material prepared as hand sheets by the T.A.P. Laboratory in Pittsfield, Mass. There was some indication that the physical properties varied somewhat with the percentage clay, and this is discussed in greater detail later in the report. Our investigations continued to explore the effects of various firing treatments followed by impregnating with various materials. These tests were performed on the sheet material or punched spacers and are discussed later in the report.

The evaluation of mica-based sheet materials was directed toward finding new types of material made available either commercially or experimentally and testing their physical properties and performance in vacuum tubes. These materials and the test results are discussed in the Detailed Section of this report.

Contacts were made with representatives of Johns-Manville, the supplier of the regular terratex raw material, in an effort to enlist their aid in obtaining machine-made samples with various clay contents. These contacts proved discouraging when they indicated that they would not undertake this type of work. This subject is being pursued with other paper manufacturers in an effort to obtain the desired materials.

Arrangements have been made to have gas analysis and thermal conductivity measurements made by the General Engineering Laboratory of the General Electric Company to determine what some of the limiting factors of the terratex and integrated mica materials might be. The results of these tests should be forthcoming in the next interval.

## Detailed Factual Data

The following descriptions identify the materials and variations investigated during the third interval of this contract.

Lot 137-1 - Terratex type material - 3.8% clay
" 137-3 - " " " - 2.3% clay
" 137-4 - " " " - 1.1% clay
" 137-5 - " " " - 4.5% clay
" 137-6 - " " " - 6.3% "
(All samples 0.011-0.013" in thickness)

Lot 138-2 - Terratex type material - 9.1% clay
" 138-3 - " " " - 4.8% "
" 138-4 - " " " - 1.0% "
" 138-5 - " " " - 2.0% "
(All samples 0.020-0.022" in thickness)

Lot 141 - Type I.N. Quinterra (no clay) - 0.012" thick
Lot 142 - " " " " " - 0.015" "
Lot 143 - Glass reinforced asbestos sheet (0.012-0.014")
Lot 145A- Terratex type material - 1.0% clay
0.019-0.021" (Hand sheets)
Lot 145B- Terratex type material 2.0% clay
0.018-0.020" (Hand sheets)
Lot 2A - Regular machine-made terratex containing
approximately 1% clay

All of the above materials were treated with ethyl silicate using the solvent method.

Variations of processing of Lot 2A material were as follows: (All variations were preceded by a 5-minute baking at 500C.)

(1) Baked 15 min at 400C followed by immersion in nitrocellulose lacquer solution.

(2) Baked 15 min at 400C followed by immersion in ethyl-silicate solution.

(3) Heated in vacuum to 550C for 3 min., cooled 3 min, and repeated for total time of 24 min., followed by flooding under vacuum with nitrocellulose lacquer solution.

(4) Same as (3) above, except flooded with ethyl-silicate solution.

Lot 121 - Silicone resin impregnated terratex
(No ethyl-silicate treatment)

Integrated or Built-up Mica

| | | |
|---|---|---|
| Lot 136B | - | GE Micamat treated with ethyl-silicate (0.006") |
| M2SH2B | - | Silicone resin treated integrated mica supplied by the Integrated Mica Corporation |
| PC2SH2B | - | Silicone resin treated integrated mica supplied by the Integrated Mica Corporation |
| NEMC Mica Plate | | Glass-bonded built-up mica flake supplied by the New England Mica Company |

The physical test results for these materials are tabulated in the following pages.

| Material | Firing Temp. | Firing Time | Bend Angle | Load at Break | Punching Characteristics and General Remarks | Degassing and Gas Content |
|---|---|---|---|---|---|---|
| Lot 136B Mica Mat (0.006") | As Rec'd | As Rec'd | 27° | 0.036# | | |
| | 450C | 5 min | 32 | 0.040 | | |
| | | 10 | 33 | 0.041 | | |
| | 500 | 5 | 24 | 0.043 | Punches cleanly. Physical strength is very poor, but looks promising if greater thicknesses are possible. | Will investigate when thicker material is available. |
| | | 10 | | | | |
| | 550 | 5 | 29 | 0.035 | | |
| | | 10 | 30 | 0.035 | | |
| M2SR2B (0.009-0.011) | As Rec'd | As Rec'd | 9 | 0.131 | Punches cleanly. Physical strength is good and contour is comparable to regular mica. | Analysis will be made. |
| | 500C | 10 | 10 | 0.177 | | |
| PC2SR2B (0.007-0.009) | As Rec'd | As Rec'd | 12 | 0.134 | Doesn't punch quite as cleanly as M2SR2B, but is acceptable. | Analysis will be made. |
| | 500 | 10 | 14 | 0.134 | | |
| Lot 121 Silicone Resin Impregnated Terratex | Not Tested | | | | As received material was too flexible and weak. Resin did not seem to penetrate sheet, and resin carbonized on heat treatment. Other silicones may be more suitable. | |
| WFMC Mica Plate 0.012-0.015 | As Rec'd | As Rec'd | Results | erratic | Material is very hard and stiff. Probably too hard to be punched economically in large quantities. | Gas content seems to be similar to regular mica. May contain impurities that would injure coated cathodes. |
| | 400 | 5 | 15 | 0.96 | | |
| | 500 | 5 | 14 | 0.52 | | |
| | 600 | 5 | 18 | 0.66 | | |

| Material | Firing Temp. | Firing Time | Bend Angle | Load at Break | Punching Characteristics and General Remarks | Degassing and Gas Content |
|---|---|---|---|---|---|---|
| Lot 137-1 (0.011-0.013) | As Received | | 55° | 0.18# | | |
| | 450C | 5 min | 25 | 0.13 | | |
| | 500 | 5 | 19 | 0.14 | | |
| | 550 | 5 | 14 | 0.07 | | |
| | 600 | 5 | 9 | 0.03 | | |
| Lot 137-3 | As Received | | 47 | 0.17 | | |
| | 450 | 5 | 19 | 0.13 | | |
| | 500 | 5 | 21 | 0.14 | | |
| | 550 | 5 | 17 | 0.10 | | |
| | 600 | 5 | 9 | 0.04 | | |
| Lot 137-4 | As Received | | 52 | 0.18 | Materials punch similarly to previous terratex samples. These sheets were thinner than we might expect to use in standard tube construction. | About the same gas content as previous samples of terratex. |
| | 450 | 5 | 26 | 0.13 | | |
| | 500 | 5 | 28 | 0.12 | | |
| | 550 | 5 | 17 | 0.10 | | |
| | 600 | 5 | 10 | 0.03 | | |
| Lot 137-5 | As Received | | 57 | 0.20 | | |
| | 450 | 5 | 25 | 0.17 | | |
| | 500 | 5 | 20 | 0.12 | | |
| | 550 | 5 | 14 | 0.08 | | |
| | 600 | 5 | 9 | 0.05 | | |
| Lot 137-6 | As Received | | 64 | 0.15 | | |
| | 450 | 5 | 29 | 0.12 | | |
| | 500 | 5 | 23 | 0.10 | | |
| | 550 | 5 | 15 | 0.07 | | |
| | 600 | 5 | 8 | 0.03 | | |
| Lot 145-A (0.021-0.023) | As Received | | 32 | 0.52 | No appreciable difference in punching characteristics between the two materials. Seems to punch cleaner than the regular Lot 2A terratex. | No noticeable difference between these two materials and Lot 2A. |
| | 400 | 5 | 22 | 0.51 | | |
| | 500 | 5 | 17 | 0.40 | | |
| | 550 | 5 | 15 | 0.37 | | |
| | 600 | 5 | 13 | 0.32 | | |

| Material | Firing Temp. | Firing Time | Bend Angle | Load at Break | Punching Characteristics and General Remarks | Degassing and Gas Content |
|---|---|---|---|---|---|---|
| Lot 145-B (0.020-0.021) | As Received | | 31° | 0.49# | No appreciable difference in punching characteristics between the two materials. Seems to punch cleaner than the regular Lot 2A terratex. | No noticeable difference between these two materials and Lot 2A. |
| | 400 | 5 min | 20 | 0.40 | | |
| | 500 | 5 | 20 | 0.36 | | |
| | 550 | 5 | 16 | 0.35 | | |
| | 600 | 5 | 14 | 0.34 | | |
| Lot 138-2 | As Received | | 26 | 0.49 | | |
| | 400 | 5 | 18 | 0.48 | | |
| | 500 | 5 | 15 | 0.38 | | |
| | 600 | 5 | 9 | 0.21 | | |
| Lot 138-3 | As Received | | 28 | 0.49 | These materials behaved similarly to previous lots of material in that the punchings were cleaner for the higher temperature firing. These samples had the best strength of any asbestos sheet tested, but this may be due to the fact that the density was about 25 percent greater than Lot 2A. | No great differences were observed as compared to Lot 2A. |
| | 400 | 5 | 17 | 0.48 | | |
| | 500 | 5 | 14 | 0.36 | | |
| | 600 | 5 | 7 | 0.21 | | |
| Lot 138-4 | As Received | | 37 | 0.36 | | |
| | 400 | 5 | 23 | 0.48 | | |
| | 500 | 5 | 18 | 0.18 | | |
| | 600 | 5 | 8 | 0.13 | | |
| Lot 138-5 | As Received | | 32 | 0.48 | | |
| | 400 | 5 | 19 | 0.42 | | |
| | 500 | 5 | 17 | 0.36 | | |
| | 600 | 5 | 7 | 0.12 | | |
| Lot 141 (0.012") | 400 | 5 | 28 | 0.18 | This material does not seem to have as good punching characteristics as the clay-containing materials. Punchings have more of a tendency to have fuzzy outlines and poor hole definition. This may be partly due to different raw materials, or manufacturing processes of the supplier | |
| | " | 10 | 31 | 0.19 | | |
| | 450 | 5 | 25 | 0.15 | | |
| | " | 10 | 22 | 0.15 | | |
| | 500 | 5 | 21 | 0.14 | | |
| | " | 10 | 19 | 0.14 | | |
| | 550 | 5 | 15 | 0.11 | | |
| | " | 10 | 12 | 0.08 | | |
| | 600 | 5 | 11 | 0.05 | | |
| | " | 10 | 10 | 0.06 | | |

| Material | Firing Temp. | Firing Time | Bend Angle | Load at Break | Punching Characteristics and General Remarks | Degassing and Gas Content |
|---|---|---|---|---|---|---|
| Lot 142 (0.015") | 400C | 5 min | 22° | 0.20 | This material does not seem to have as good punching characteristics as the clay-containing materials. Punchings more of a tendency to have fuzzy outlines and poor hole definition. This may be partly due to different raw materials, or manufacturing processes of the supplier. | |
| | " | 10 | 23 | 0.20 | | |
| | 450 | 5 | 20 | 0.19 | | |
| | " | 10 | 19 | 0.18 | | |
| | 500 | 5 | 18 | 0.18 | | |
| | " | 10 | 17 | 0.18 | | |
| | 550 | 5 | 14 | 0.13 | | |
| | " | 10 | 11 | 0.12 | | |
| | 600 | 5 | 10 | 0.19 | | |
| | " | 10 | 8 | 0.08 | | |
| Lot 143 | Not Tested | | | | Material was too thin and weak to be usable. | |

| Material | Before Impregnation Temp. | Before Impregnation Time | After Impregnation Temp. | After Impregnation Time | Bend Angle | Load at Break | Comments |
|---|---|---|---|---|---|---|---|
| Lot 2A Terratex | 400C | 5 min | 175C | 15 Min | 22° | 0.26 | |
| | 500 | 5 | " | " | 20 | 0.24 | |
| | 550 | 5 | " | " | 17 | 0.31 | |
| | 600 | 5 | " | " | 15 | 0.23 | The addition of the ethyl silicate seems to increase the strength and stiffness, but when the material is fired the second time at temperatures of 400C or above, these effects are almost lost. No improvement in gas content or ease of degassing was observed with the samples. |
| Impregnated while hot with ethyl silicate | 400 | 5 | 300 | 15 | 18 | 0.22 | |
| | 500 | 5 | " | " | 18 | 0.24 | |
| | 550 | 5 | " | " | 17 | 0.22 | |
| | 600 | 5 | " | " | 17 | 0.23 | |
| | 400 | 5 | 400 | 15 | 25 | 0.18 | |
| | 500 | 5 | " | " | 25 | 0.19 | |
| | 550 | 5 | " | " | 23 | 0.20 | |
| | 600 | 5 | " | " | 20 | 0.15 | |
| | 400 | 5 | 500 | 15 | 29 | 0.17 | |
| | 500 | 5 | " | " | 31 | 0.15 | |
| | 550 | 5 | " | " | 26 | 0.17 | |
| | 600 | 5 | " | " | 21 | 0.14 | |

The preceding physical data indicate that the samples of M2SH2B and PC2SH2B integrated mica have physical properties suitable for vacuum tube spacers. Because the thickness of these materials is more uniform, they would be somewhat easier to handle in the normal manufacturing operations.

The data on the terratex materials with various percentages of clay seem to indicate that there is some variation of strength with clay content. However, these were hand sheets and do not necessarily indicate what we might experience on machine-made material. In general, the strength and stiffness increased with the percentage of clay.

No apparent advantages are evident for the no-clay asbestos materials and they appear to have poorer punching characteristics.

The effect of firing the terratex and giving it a second ethyl-silicate treatment seems to be desirable from the strength standpoint, but may be objectionable in tubes.

## Tube Data

The JAN test limits for the two tube types for which data are presented are as follows:

| Type 5654 | Type 12AT7 |
|---|---|
| -Ig = 0.1 ua | -Ig = 2.25 ua |
| Ip = 3-12 ma | Ip = 7-14 ma |
| Sm = 3500-6500 umhos | Sm = 4500-6500 umhos |
| 5.5 Sm = 3150 umhos | 11 Sm = 4000 umhos |
| | Is = 50 ma |

Type SD-61 (5654) tubes were made with the following spacer materials. All samples were made from Lot 2A terratex.

Group 1 - Plain terratex
Group 2 - $Al_2O_3$ sprayed terratex
Group 3 - Vacuum fired nitrocellulose lacquer-impregnated terratex
Group 4 - Air baked nitrocellulose lacquer-treated terratex
Group 5 - Air baked ethyl-silicate-treated terratex
Group 6 - Control group - regular mica

There was an average of 12 tubes in each lot, but data for only 5 of each lot are presented to show the general results for each group.

**GROUP 1**

| -Ig | Ip | Sm | 5.5 Sm |
|---|---|---|---|
| 0 | 7.4 | 4850 | 3780 |
| 0.3 | 8.5 | 5520 | 3530 |
| 0 | 3.8 | 2380 | 1450 |
| 0 | 6.7 | 4310 | 3040 |
| 0 | 4.0 | 2330 | 1080 |

**GROUP 2**

| -Ig | Ip | Sm | 5.5 Sm |
|---|---|---|---|
| 0 | 5.0 | 2560 | 1070 |
| 0 | 4.4 | 2450 | 490 |
| 0 | 4.25 | 2470 | 1060 |
| 0.05 | 5.25 | 2430 | 1050 |
| 0 | 5.8 | 4060 | 2320 |

**GROUP 3**

| -Ig | Ip | Sm | 5.5 Sm |
|---|---|---|---|
| 0 | 4.4 | 2480 | 1360 |
| 0 | 6.65 | 4050 | 2090 |
| 0 | 4.5 | 2930 | 1590 |
| 0 | 6.8 | 4130 | 3120 |
| 0 | 5.0 | 2960 | 1700 |

**GROUP 4**

| -Ig | Ip | Sm | 5.5 Sm |
|---|---|---|---|
| 0 | 1.8 | 720 | 300 |
| 0 | 4.8 | 3110 | 1650 |
| 0 | 3.5 | 1660 | 750 |
| 0 | 5.8 | 2930 | 1400 |
| 0 | 1.7 | 910 | 380 |

**GROUP 5**

| -Ig | Ip | Sm | 5.5 Sm |
|---|---|---|---|
| 0 | 7.3 | 4010 | 2110 |
| 0 | 6.7 | 3370 | 1920 |
| 0 | 6.2 | 3940 | 2910 |
| 0.2 | 9.6 | 4710 | 3270 |
| 0 | 8.6 | 4380 | 2470 |

**GROUP 6**

| -Ig | Ip | Sm | 5.5 Sm |
|---|---|---|---|
| 0 | 6.5 | 3840 | 2560 |
| 0.01 | 9.0 | 4800 | 3890 |
| 0 | 6.6 | 3490 | 2370 |
| 0 | 6.5 | 3570 | 2340 |
| 0 | 6.1 | 3560 | 2100 |

All of the tubes, including the control group, were unacceptable because of low transconductance and reduced transconductance. Group 5 was very close to the control group for this small test and might prove to be almost identical on a larger test. No conclusions have been drawn for the poor results on this group of tubes. Further tests will be necessary to determine the possible cause of these results.

Tests were made on type SD-6C (12AT7) tubes which were processed on the bench exhaust equipment unless otherwise noted.

The following results were obtained on type SD-60C using regular mica, M2SH2B, and PC2SH2B integrated mica as spacer materials.

**REGULAR MICA**

| -Ig | Ip | Sm | 11 Sm | Ig |
|---|---|---|---|---|
| 0 | 10.3 | 5890 | 5580 | 130 |
| 0 | 8.3 | 5580 | 5080 | 108 |
| 0 | 0.4 | 5240 | 4490 | 100 |
| 0.02 | 9.7 | 5890 | 5450 | 100 |
| 0 | 10.2 | 5640 | 5160 | 102 |

**M2SH2B INTEGRATED MICA**

| -Ig | Ip | Sm | 11 Sm | Ig |
|---|---|---|---|---|
| 1.9* | 9.4 | 5330 | 4860 | 38 |
| 0.9* | 9.0 | 5200 | 4600 | 54 |
| 1.5* | 9.3 | 5030 | 4060 | 38 |
| 1.55* | 9.6 | 5270 | 4750 | 85 |
| 1.70* | 9.8 | 5160 | 4400 | 65 |

**PC2SH2B INTEGRATED MICA**

| -Ig | Ip | Sm | 11Sm | Ig |
|---|---|---|---|---|
| 1.7* | 9.4 | 5010 | 3340 | 97 |
| 2.4* | 9.7 | 5200 | 4700 | 65 |
| 2.15* | 9.5 | 5170 | 4680 | 55 |
| 2.00* | 9.3 | 5180 | 4700 | 90 |
| 2.1* | 9.7 | 5250 | 4780 | 88 |

*Indicates leakage as opposed to gas.

The results of this test show the high leakage characteristics of the two integrated mica materials. Also, somewhat reduced emission is apparent, particularly with the M2SH2B material. This may be due to greater thermal conductivity of the material or to a partial poisoning of the oxide-coated cathode. Fig. 1 shows the effect of heater voltage on the transconductance of these tubes and verifies the results shown here. Further tests will be necessary to determine which of the above mentioned factors is causing these results.

In an attempt to minimize the interelement leakage, additional type SD-6CC tubes were made with M2SH2B spacers that were given a special degreasing, air firing, and MgO spray.

| REGULAR MICA | | | | | M2SH2B INTEGRATED MICA | | | | |
|---|---|---|---|---|---|---|---|---|---|
| -Ig | Ip | Sm | 11Sm | Is | -Ig | Ip | Sm | 11Sm | Is |
| 0 | 10.0 | 5010 | 4540 | 90 | 0 | 9.3 | 4660 | 4300 | 60 |
| 0 | 9.0 | 4900 | 4350 | 98 | 0 | 9.45 | 5120 | 4340 | 92 |
| 0 | 8.4 | 4650 | 4360 | 80 | 0 | 8.2 | 4240 | 3590 | 29 |
| 0 | 9.8 | 4830 | 4640 | 103 | 0.02 | 7.9 | 4410 | 3430 | 25 |
| 0 | 8.0 | 4460 | 4120 | 65 | 0 | 12.2 | 4960 | 4490 | 65 |

A complete analysis of 19 tubes in each lot (38 sections) gave the following median values:

| | -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|---|
| Regular Mica | 0 | 8.8 | 4900 | 4400 | 90 |
| M2SH2B | 0 | 8.6 | 4800 | 4000 | 60 |

It was encouraging to observe the marked reduction in interelement leakage in these tubes, but the reduced emission characteristics are still a cause for concern.

A third test was undertaken to determine the results of these materials in tubes produced on automatic exhaust equipment. The special processing of the integrated mica spacers was applied to this test.

| REGULAR MICA | | | | | M2SH2B INTEGRATED MICA | | | | |
|---|---|---|---|---|---|---|---|---|---|
| -Ig | Ip | Sm | 11Sm | Is | -Ig | Ip | Sm | 11Sm | Is |
| 0.02 | 10.1 | 5260 | 4970 | 100 | 0.35 | 10.0 | 5310 | 5010 | 77 |
| 0.02 | 10.25 | 5240 | 4790 | 102 | 0.30 | 11.2 | 5650 | 5250 | 62 |
| 0 | 10.85 | 5180 | 4830 | 87 | 0.02 | 9.1 | 4860 | 4460 | 50 |
| 0.01 | 10.8 | 5040 | 4860 | 90 | 0.08 | 8.7 | 4630 | 4100 | 50 |
| 0 | 10.0 | 5230 | 5030 | 95 | 0.30 | 9.35 | 4150 | 7880 | 30 |

| PC2SH2B INTEGRATED MICA | | | | |
|---|---|---|---|---|
| -Ig | Ip | Sm | 11Sm | Is |
| 0.30 | 11.2 | 5190 | 4840 | 65 |
| 0.02 | 10.1 | 5320 | 4990 | 72 |
| 0.10 | 9.9 | 5160 | 4950 | 75 |
| 0.05 | 10.5 | 5190 | 4950 | 80 |
| 0.12 | 10.45 | 5420 | 5120 | 80 |

A complete analysis of approximately 20 tubes in each lot (40 sections) gave the following median values:

| | -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|---|
| Regular Mica | 0.05 | 10.0 | 5150 | 4850 | 95 |
| M2SH2B | 0.30 | 9.4 | 5000 | 4500 | 55 |
| PC2SH2B | 0.10 | 10.2 | 5150 | 4850 | 75 |

Again the integrated mica materials resulted in somewhat lower emission [illegible]racteristics with the PC2SH2B material being superior to the M2SH2B. More [illegible]damental information will have to be obtained before conclusions as to the [illegible]se of these results can be drawn.

Tests on asbestos-based materials, i.e. terratex, were also conducted on [illegible]e SD-6C (12AT7) tube type with the following results:

Group 1 - Regular mica, control group
2 - Plain terratex
3 - Vacuum fired, ethyl-silicate impregnated terratex

GROUP 1

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0.01 | 9.9 | 5060 | 4720 | 90 |
| 0.05 | 9.7 | 4900 | 4360 | 80 |
| 0 | 9.1 | 4620 | 4220 | 85 |
| 0 | 9.0 | 4820 | 4400 | 95 |
| 0.05 | 9.7 | 4970 | 4750 | 75 |

GROUP 2

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0.04 | 10.5 | 5570 | 4340 | 105 |
| 0.02 | 9.0 | 4980 | 4630 | 90 |
| 0.03 | 9.1 | 5110 | 4540 | 110 |
| 0.04 | 10.2 | 5150 | 4820 | 105 |
| 0.02 | 9.7 | 5300 | 4930 | 100 |

GROUP 3

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0 | 9.2 | 5040 | 4620 | 90 |
| 0.03 | 10.0 | 5320 | 4860 | 100 |
| 0.01 | 9.5 | 5000 | 4590 | 85 |
| 0.02 | 9.3 | 5250 | 4730 | 105 |
| 0 | 9.1 | 5130 | 4720 | 100 |

Some improvements in gas content and ease of degassing were observed during the exhaust processing of the Group 3 tubes over the Group 2 tubes. The initial test data are encouraging, and life test information will be obtained.

In an effort to decrease the moisture content and keep it low, two silicone water-proffing agents were used to treat the terratex. The materials were "Dry Film" and "Soda T," both obtainable from the General Electric Company's Chemical Department.

No improvement in ease of degassing the tube was apparent during the exhaust processing. Tests on the tubes showed the Dry Film treated terratex-spaced tubes to have no emission. The Soda T treated terratex-spaced tubes compared with other terratex tubes and regular mica. No benefits were apparent from this added treatment.

Because Lot 138 terratex samples had been the best of the terratex materials with various percentages of clay added to the asbestos, type SD6CF (12AT7) tubes were made to determine what differences in degassing and tube characteristics might be obtained with these variations. These tubes were identified as follows:

Group 1 - Regular Mica, Control Group
" 2 - Terratex with 9.1% Clay
" 3 - Terratex with 4.8% Clay
" 4 - Terratex with 1.0% Clay
" 5 - Terratex with 2.0% Clay

No difference in ease of degassing or gas content was discerned during the exhaust processing of the terratex spaced tubes. The following electrical test data were obtained:

GROUP 1

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0.03 | 9.6 | 4760 | 4340 | 80 |
| 0 | 9.6 | 4860 | 4620 | 65 |
| 0 | 9.7 | 4750 | 4500 | 80 |
| 0.25 | 9.1 | 4650 | 3070 | 80 |
| 0 | 8.1 | 4310 | 3800 | 65 |

GROUP 2

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0.25 | 9.8 | 4880 | 4440 | 75 |
| 0.02 | 8.1 | 4520 | 4020 | 65 |
| 0 | 8.4 | 4670 | 4350 | 35 |
| 0 | 7.6 | 4330 | 3880 | 50 |
| 0 | 11.9 | 4310 | 3980 | 72 |

GROUP 3

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0 | 8.75 | 4500 | 4130 | 58 |
| 0.05 | 9.2 | 4820 | 4310 | 62 |
| 0 | 8.1 | 4070 | 3730 | 50 |
| 0 | 8.8 | 4570 | 4210 | 62 |
| 0 | 8.7 | 4760 | 4950 | 82 |

GROUP 4

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0.10 | 8.3 | 4130 | 3600 | 30 |
| 0.12 | 8.4 | 4560 | 4020 | 45 |
| 0 | 7.5 | 4220 | 3830 | 49 |
| 0.10 | 7.7 | 3910 | 3500 | 40 |
| 0 | 8.2 | 4540 | 4110 | 50 |

GROUP 5

| -Ig | Ip | Sm | 11Sm | Is |
|---|---|---|---|---|
| 0 | 7.4 | 4400 | 3950 | 25 |
| 0 | 8.7 | 4610 | 4320 | 70 |
| 0 | 8.42 | 4640 | 4310 | 68 |
| 0 | 8.2 | 4450 | 3800 | 45 |
| 0 | 9.2 | 4890 | 4480 | 80 |

The results on this test were somewhat erratic, and since the number of tubes was small (less than 10 tubes/group), it is difficult to draw definite conclusions. The data for all the tubes does indicate that possibly Group 5 was the best of the terratex materials. More tests with larger numbers of tubes will be needed to establish this conclusively. These tests will be made when larger samples of sheet material are available.

Type SD-6CC (12AT7) tubes were also made to compare the NEMC plate with regular sheet mica. The data are not presented because the tubes with the NEMC material spacers had practically no emission. Further investigation of this material does not seem warranted at this time.

From the preceding data, several materials show promise, and further testing of these will continue. The initial test results on the M2SH2B and PC2SH2B materials indicate the need for more tests. Life tests on tubes using these materials should be made. Also, life test data will be taken on tubes using the vacuum fired, ethyl-silicate impregnated terratex since the tubes look satisfactory initially. Further tests on the variation of clay content in the terratex type material will continue in an effort to obtain the best overall characteristics.

## Conclusions

The two types of integrated mica, M2SH2B and PC2SH2B, gave tubes that were satisfactory initially but not as good as the regular mica control tubes. The need for for thorough degreasing and spraying the surface to reduce leakage on these two materials is evident. The PC2SH2B material appears to give results more nearly like sheet mica than does the M2SH2B.

Additional tests on the SD-6C (12AT7) and other types, particularly life tests, are necessary to determine limitations of the integrated mica materials.

Results on the NFMC Mica Plate were discouraging, and no advantages over the two integrated mica materials are evident. No additional tests seem warranted at this time.

Some improvement in ease of degassing and gas content has been made on the terratex material by a process of vacuum firing and a second ethyl-silicate impregnation. Further improvement is still desirable.

Variations in clay content of the terratex sheets affect the physical properties of this material and additional samples should be obtained.

## Work to be Performed During Next Interval

Additional evaluation of the two integrated mica materials with particular emphasis on the thermal conductivity and gas analysis measurements.

Continuation of the investigation of new processing of the .020" terratex in an effort to further increase physical strength and ease of degassing.

Analyzation of the gases given off by the terratex under high vacua at elevated temperatures to learn what gases are present, thus indicating what constituents might be eliminated.

Evaluation of machine made samples of terratex with varying clay content for effects on spacer material.

Continuation of investigation of new materials that indicate promise as tube spacers.

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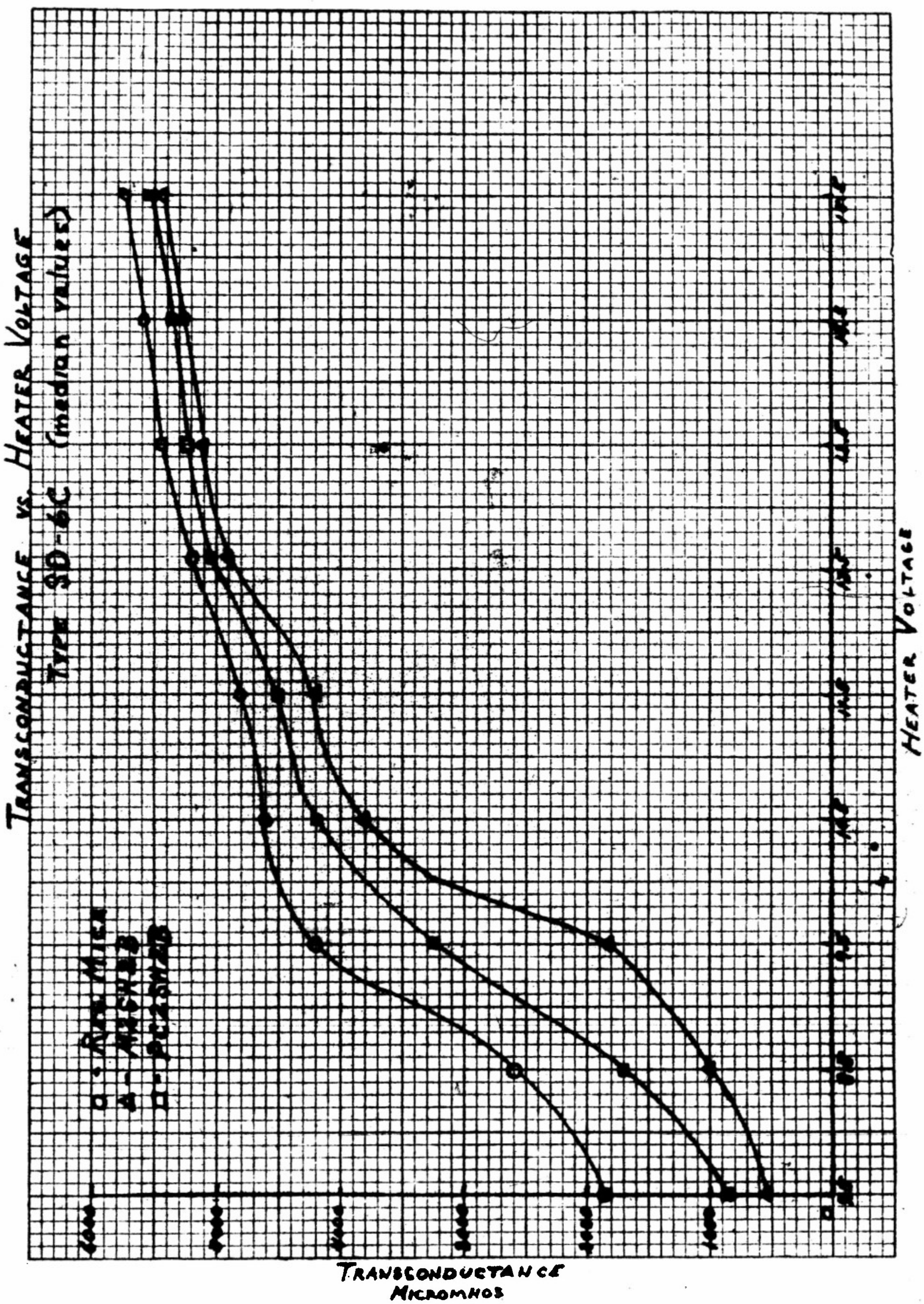


Fig. 1